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Received: 14 Nov. 2011
Accepted: 28 Feb. 2012
Editor: R. Causse

Range extensions of four species of parrotfishes (Scaridae) in the northern Gulf of California, Mexico

by

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RÉSUMÉ. - Nouvelles extensions de la distribution géographique de quatre espèces de poissons-perroquets (Scaridae) dans le nord du golfe de Californie, Mexique.

Cet article présente de nouvelles extensions de la distribution géographique de quatre espèces de poissons-perroquets (Scaridae) dans le golfe de Californie, Mexique : *Scarus compressus*, *S. ghobban*, *S. perrico* et *S. rubroviolaceus*. La présence de ces espèces dans la partie nord du golfe est importante si nous considérons leur rôle écologique en tant que consommateurs d'algues et de mollusques, mais aussi comme producteurs de sédiments carbonatés dans les récifs coralliens, rôle qui n'est joué par aucun autre poisson dans cette zone. Ces signalements d'espèces du genre *Scarus* pourraient indiquer que les conditions océanographiques dans le nord du golfe de Californie deviennent acceptables pour les espèces tropicales. Par conséquent, nous pouvons supposer qu'il pourrait se produire un élargissement de la répartition géographique de plusieurs autres espèces de poissons dans les années à venir.

Key words. - Scaridae - *Scarus compressus* - *Scarus ghobban* - *Scarus perrico* - *Scarus rubroviolaceus* - Gulf of California - Mexico - Reef fishes - Zoogeography.

The parrotfishes, family Scaridae, are species of great ecological importance in coral reefs worldwide. According to Eschmeyer (2011) there are 97 species in this family, belonging to 9 genera. They have a varied diet but usually feed on coralline algae, corals, bivalves and other invertebrates (Froese and Pauly, 2011). In the eastern Pacific Ocean there are six species of the family (Robertson and Allen, 2008): *Calotomus carolinus* (Valenciennes, 1840), *Nicholsina denticulata* (Evermann & Radcliffe, 1917), *Scarus compressus* (Osburn & Nichols, 1916), *S. ghobban* Forsskål, 1775, *S. rubroviolaceus* Bleeker, 1847 and *S. perrico* Jordan & Gilbert, 1882, all of them present in western Mexico.

There have been many studies on community structure of reef fishes in the Pacific coast of Mexico (Pérez-España *et al.*, 1996; Galván-Villa *et al.*, 2010), and most refer to *Scarus* species as abundant or common at the sites. However, efforts conducted at latitudes higher than 26°N within the Gulf of California, or 24°N in the Pacific side of the Baja California Peninsula (Viesca-Lobatón *et al.*, 2008; Reyes-Bonilla *et al.*, 2010) show the lack of representatives of this family in said regions, a fact attributed to low winter temperatures that prevent tropical species from settling successfully. At the same time, in recent years there have also been a number of range extensions of fish species in both cited areas (Rodríguez-Romero *et al.*, 2008; Amezcua-Linares and Amezcua, 2009), and share the condition that these taxa commonly reside in lower latitudes but have been able to disperse north. The goal of this paper is to continue documenting this phenomenon by recording range extensions of four species of parrotfishes in rocky reefs in the northern Gulf of California, Mexico.

Baseline data was gathered during a cruise taken in June 14-24, 2010, that circled the northern Gulf of California while visiting 27 sites in these islands: La Poma, Ángel de la Guarda, Salsipuedes, San Lorenzo in Baja California (west side of the gulf), and San Esteban, San Pedro Mártir, Dátil, Tiburón, Patos and San Jorge, in Sonora (east side). Latitudinal boundaries for this study were 28.35°N (San Pedro Mártir Island) and 31.03°N (San Jorge Island). Between 15 and 71 belt censuses 30 m long by 2 m wide were carried out at each reef visited (N = 626), at depths of 5 and 20 m. In addition, we considered records of underwater fish monitoring conducted between March and June, 2007, in 14 sites along the coast of Sonora (from Dátil Island to El Borrascoso; 28.70°N, 112.28°W to 31.47°N, 114.03°W, respectively; N = 317 censuses), in 19 sites in the Bahía de los Ángeles, Canal de Ballenas and Salsipuedes Biosphere Reserve (28.79°N, 113.19°W to 29.28°N, 113.64°W; N = 249 censuses; visits between 2006 and 2009), and in 15 sites at San Lorenzo Archipelago National Park (28.57°N, 112.77°W to 28.89°N, 113.03°W; N = 209 censuses; visits between 2009 and 2010). Identification of organisms was done in situ, based on illustrations by Allen and Robertson (1994), Thomson *et al.* (2000) and Humann and DeLoach (2004). Lastly, to denote the northern limit in species distribution, georeferenced records were revised in Robertson and Allen (2008), Fishbase (Froese and Pauly, 2011), the Global Biodiversity Information Facility (GBIF, 2011) and the Ocean Biogeographic Information System (OBIS, 2011) databases that include data from the Colección Nacional de Peces, Universidad Nacional Autonóma de México (IBUNAM); the Colección Ictiológica, Centro Interdisciplinario de Ciencias Marinas, Instituto Politécnico Nacional (CICIMAR-IPN); the United States National Museum of Natural History (USNM); the Scripps Institution of Oceanography (SIO), the Los Angeles County Museum of Natural History (LACM), and the Santa Barbara Museum of Natural History (SBMNH).

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Cybium 2013, 37(3): 223-226.

Table I. - Northern distribution range limit comparison for *Scarus* spp., based on bibliography and databases consulted, and data from the field (2009-2010). Sizes (total length) in centimeters. Acronyms: GBIF: Global Biodiversity Information Facility. IBUNAM-CNPE: Colección Nacional de Peces. Instituto de Biología, Universidad Nacional Autónoma de México.

Species	Northernmost limit reported	Range extensions
S. compressus	28.22°N, 111.07°W (Robertson and Allen, 2008)	- San Jorge Island (31.10°N, -113.15°W; 6 m depth. Two 30 cm specimens. 2010) - Punta del Diablo, Ángel de la Guarda Island (29.17°N, -113.11°W; 6 m depth. One 40 cm specimen. 2010)
S. ghobban	27.27°N, 112.12° W (GBIF; IBUNAM-CNPE-5186)	- La Poma Island (30.01°N, -114.39°; 9 m depth. One 30 cm specimen. 2010) - Patos Island (north of Tiburón Island. 29.26°N, -112.46° W; 6 m depth. Two specimens, 40 and 50 cm respectively. 2007, 2010) - La Reina, Tiburón Island (29.07°N, -112.51°W; 12 m depth. One 40 cm specimen. 2007) - La Tordilla, Tiburón Island (28.88°N, -112.57°W; 17 m depth. One 40 cm specimen. 2010) - Arroyo El Cartelón, San Pedro Mártir Island (28.39°N, -112.31°W. Three 15 cm specimens and two 20 cm specimens. 2010)
S. perrico	28.17°N, -111.30°W (Robertson and Allen, 2008)	- La Poma Island (30.01°N, -114.39°W; 9 m depth. One 35 cm specimen. 2010) - El Chivero, north of Los Ángeles Bay (29.36°N, -113.72°W; 10-11 m depth. Nine specimens, one 30 cm, four 40 cm and four 50 cm. 2009)
S. rubroviolaceus	27.38°N, -109.92°W (GBIF; IBUNAM-CNPE-5510)	- San Pedro Mártir Island (28.38°N,- 112.32°W. 8 m depth. 2010)

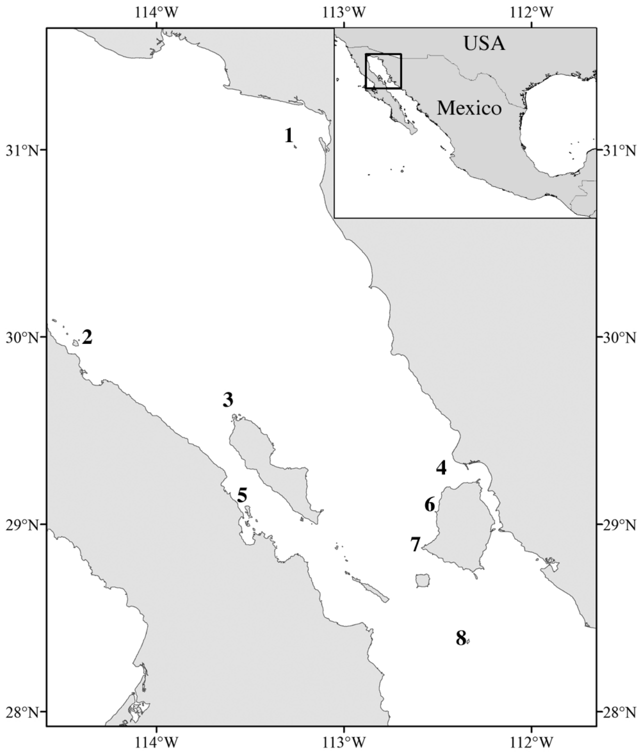

Figure 1. - Location of sites cited in table I, where the new records were gathered. 1) San Jorge, 2) La Poma, 3) Punta del Diablo, 4) Patos Island, 5) El Chivero, 6) La Reina, 7) La Tordilla, 8) San Pedro Mártir.

The field trips showed the presence of all four *Scarus* species in areas north from the maximum northern limit known in the Gulf of California (Tab. I). In all cases, the new occurrence sites are at least 100 km further away from what is described in publications and databases, stressing the importance of the findings. Sizes of observed or photographed specimens varied from 10 to 50 cm long (Tab. I). All parrotfish species were uncommon as they appeared in only 11 of the 75 analysed sites (Fig. 1), and were considered rare in their sites of observation (between one and three individuals seen while diving). For that reason the finding of two species (*S. perrico* and *S. ghobban*) during the same visit to La Poma in 2010 (30.01°N-114.39°) also drew our attention.

The parrotfish species were seen in one (*S. perrico, S. rubroviolaceus*), two (*S. compressus*), and five (*S. ghobban*) new sites located north from the known distribution range, and taking individual sizes into account (Tab. I), most specimens were adults. Taking all years into account, the species mainly extended their distribution range along the coast of Sonora (western Gulf of California), except for *S. rubroviolaceus*, which also appeared in northeastern Baja California in 2010.

Although all consulted databases, museum catalogues and many well known publications (e.g. Allen and Robertson, 1994; Humann and DeLoach, 2004) indicate that no *Scarus* occurs north of 28°N, Thomson *et al.* (1979, 2000) mentions of the presence of *S. perrico* at Puerto Lobos and Puerto Peñasco (no coordinates given but probably circa 30°15’, -112°51’, and 31°20’, -120°38’, respectively). Those records have been overlooked or probably not considered as valid, but nevertheless our observations support them; taken together, the data point out to the presence of this parrotfish in the northern gulf since decades ago.

There is not much information about recent changes in the geographic range for the species studied, except for *S. ghobban*. This fish arrived to the Mediterranean Sea very recently (Bariche and Saad, 2008), and probably came from the Red Sea and Indian Ocean, where its populations maintain a relatively long distance genetic flow because of the direction of currents. Also, this parrotfish has undergone significant geographic expansions worldwide after the Pleistocene (Visram *et al.*, 2010). For the Gulf of California, Ayala-Bocos and Reyes-Bonilla (2009) developed a model predicting changes in distribution for *S. ghobban*, among other species, and point out that this is among the fishes with highest potential of expanding its distribution range in the gulf as temperature rises.

The occurrence of scarid fish in areas of the northern Gulf of California, where they had not been observed before, may have several explanations. Initially, the new findings could be the result of a higher sampling effort when compared to earlier historical efforts, or surveys conducted by more knowledgeable divers, actively looking for species they are familiar with. However, that is not the case; the northern gulf has been extensively studied by Mexican and US researchers since the early 1970 (Thomson *et al.,* 1979, 2000; Lindsay and Engstrand, 2002), all of them recognized experts in the field, and notwithstanding to date there are no records of the target species in the northern gulf. Another possibility is that environmental conditions in the past were not adequate for the occurrence of these fishes, as in the early to mid 1900s, ocean salinity in the study region was lower as the area received the input of fresh water from the Colorado River (Thomson *et al*., 1979); a situation that may have not allow the expansion of *Scarus* to the north. Nevertheless, biogeochemical traces in sediments of the northern gulf evidence that the area increased its salinity to current levels well before the 1980s (Carriquiry and Sanchez, 1999).

Considering the presented arguments we suggest that our records might result from the region's warming in recent years, especially along the eastern coast where elevation rate has been 0.01°C/year between 1984 and 2008 (data from the Reynolds Weekly Sea Surface Temperature from NOAA NCEP). Thus, the observed fishes could be potential founders of new populations. Another possibility is that the low number of specimens observed and their large size (adults) indicates no established populations but specimens that have temporarily drifted outside their distribution range. The exception is *S. ghobban*, which was seen around Tiburón Island in 2007 and 2010, and has possibly immature specimens in San Pedro Mártir Island. A higher number of observations is needed to accept or discard any of this hypotheses.

The occurrence of tropical species in areas usually out of their distribution has been interpreted as colonization aided by global change. Arvedlund (2009) considers that this type of information can be relevant but must be substantiated with evidence of environmental change in new recording sites, and even uses *S. ghobban* as an example. With regard to our case, warming of the northern gulf must be causing more suitable conditions for tropical species, drawing attention to possible occurrence of new findings in years to come.

Arrival of parrotfishes to the northern Gulf of California is a phenomenon of ecological relevance, since these species are known for their roles as algae and mollusk consumers, and also because they bioerode carbonated substrates and generate great quantities of sediment (Hoey and Bellwood, 2008). Currently, there is no fish in the northern part of the gulf that carries out this function, and therefore a potential increase in the number of herbivore scarids could generate a change in algae biomass in that region.

In conclusion, recent assessments of reef communities in the northern Golf of California show occurrence of four species of Scaridae further north from their known distribution range. It is possible that these range extensions are related to the increase in ocean temperature that the coast of Sonora has undergone in recent decades, possibly facilitating the arrival of tropical species to these latitudes.

Acknowledgements. - The authors appreciate the support provided by the David and Lucille Packard Foundation to conduct the 2007 and 2010 PANGAS cruises, and funding from Pronatura Noroeste to carry out assessments in Bahía de los Angeles, Isla San Lorenzo and surroundings, and for a scholarship granted to the first author to conduct her undergraduate thesis. Arturo Ayala (UABCS), Gustavo Danemann (Pronatura Noroeste, A.C.) and Jorge Torre (COBI, A.C., Guaymas) provided comments to preliminary versions of this note.

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